Understanding and building the OCF dipole antenna

Ron Bertrand VK2DQ

Want to build a simple, efficient, multiband antenna?

One of the best inexpensive multiband antennas is the off-centre-fed (OCF) dipole. These are wonderfully simple antennas that permit multiband operation with little or no tuning. The OCF dipole does require a balun. In fact the only difficult part of an OCF dipole is the balun and I will be explaining how the balun works and also how you can make your own. We shall see how many choose to either use a 4:1 or 6:1 balun for an OCF dipole. I use an OCF dipole with a 4:1 balun and find it works very well and the 4:1 balun is a bit smaller, lighter and cheaper to construct than a 6:1. However for those who want to construct a 6:1 balun I will explain how that can be done as well. Before we get going let us try and understand what the OCF dipole is all about. It all started with the Windom antenna.

Windom Antenna

The Windom was once a very popular multiband antenna. The antenna is named after its inventor, Loren G. Windom W8GZ, who first published details of his antenna design in 1929. The Windom is just a horizontal half-wave of wire on the lowest frequency of operation. The Windom uses a single wire as the alleged feedline. Instead of being fed in the centre the single wire 'feeder' is attached to the dipole 14% off centre. See Figure 1.

There is no transmission line used on the original Windom. A single wire is attached 14% off the centre of the dipole. This wire feeder is then connected to an antenna tuning unit (ATU). The idea of feeding the half-wave off centre was to find a point where the impedance "is easier for the tuner to cope with" across multiple bands which are related to even harmonic lengths of the dipole. The Windom was an 80-metre antenna. The single wire was thought to have an impedance of 600 ohms against ground.

The logic goes like this: since the centre of a dipole is about 70 ohms and the ends 2-3000 ohms, the theory goes that we should be able to find any impedance between these two extremes along the antenna. The theory is good but we need to translate it into practice. So a point could be found, presumed to be 14% off centre, where the feedpoint impedance was 600 ohms. While the theory might sound good I have some difficulty with this hypothesis. First the feedpoint is not at the antenna. The feedpoint is at the station end of the vertical wire. The so-called feeder of the Windom is a radiator as much as the half-wave top section. The feeder on the original Windom was supposed to come away from the dipole at right angles for at least one half the length of the antenna; in other words, a quarter wave. I am a bit lost regarding the reason for this distance, but I can easily see the Windom as a vertical wire antenna with a large capacitive hat. Still the antenna enjoyed a lot of popularity for many years because it did work with an ATU. It could be tuned on multiple bands.

However, so could almost any bit of wire, if high voltage points were avoided. A high voltage point occurs when the wire length is a half-wave long or multiple thereof; in other words, a high impedance point. Since the feeder wire radiates there will be RF radiation in the shack. With today's concerns about the potential dangers of electromagnetic radiation, this should be avoided. The old-style Windom would not meet our present-day EMR safety requirements if you are using 100 watts or more. Indeed my first introduction to the Windom was at a Jamboree of the Air around 1976. That was the year I received my first RF burn as a direct consequence of placing my forearm close to the "feeder" wire of the Windom while the station was transmitting. While it hurt, I did think it was cool at the time. I felt like I had been initiated to the RF burn club. Such a risk is not acceptable today. RF energy can cause cumulative and permanent damage to tissues of the body.

It is often said about antennas like the Windom that they are "worked against their image in the ground". I think statements like that are most confusing. It conjures up a picture of something actually being in the ground.

A Windom is just a horizontal half-wave without a real transmission line. It is not really a half-wave antenna because its so-called feeder radiates and is, therefore, part of the antenna. Like most antennas, reflection of radiation from the ground modifies the radiation pattern. That is what is meant by "it works against its image".

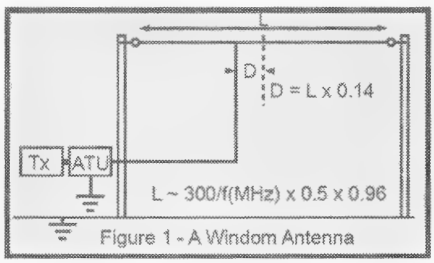

Figure 1: The schematic of a Windom antenna.

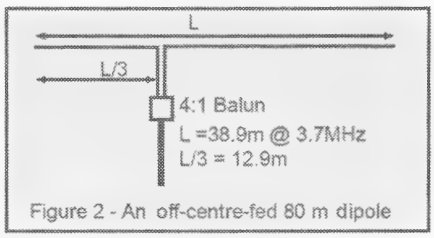

Figure 2: The schematic of an Off-Centre-Fed 80 metre dipole.

So why talk about the Windom if we are not going to rate it well? The principle of finding a point on an antenna where an acceptable or workable impedance match can be obtained across multiple bands is sound. This was the objective with the Windom. Find a point on a dipole that will permit the best multiple-band operation. Did the Windom achieve this? Well, I suppose it did but without an antenna tuner and the more robust transmitter output tuning found in older transmitters you would have trouble with a Windom today.

An improvement on the Windom is the Off-Centre-Fed Dipole or just OCF.

Off-Centre-Fed Dipole

OCFs are a descendant of the Windom. A standard horizontal dipole is fed at a position other than the centre. The objective being to find an impedance on the antenna that can provide a reasonably good match to the transmitter across multiple bands which are even harmonically related, such as 80, 40, 20 and 10 metres. The idea of feeding an antenna off-centre is not new but for some, at least at first, it appears odd. A half-wave antenna is a resonant antenna irrespective of where it is fed. The end of a dipole is 2-3000 ohms and resistive. The centre is about 70 ohms and resistive. Between the centre and the end you could find any resistive impedance between these two extremes (70-3000 ohms).

So, if we wanted to find a point that was 300 ohms and resistive theoretically we could do it. Indeed the idea is not new. For example, delta and gamma matches use this principle. A Quad loop can be fed at the centre of one side (125 ohms) or at a corner (144 ohms) to find an appropriate feedpoint impedance. When we change the feedpoint position on a Quad, we are changing the feedpoint impedance. The resonance and other characteristics of the Quad loop are not substantially changed by the feedpoint we choose. This is how it is with a dipole as well.

How far off-centre?

The exact position off centre seems to vary somewhat and would seem to be a matter of debate. The length of the dipole is based on the standard length equation.

$$l = \frac{300 \times 0.5 \times 0.96}{f}$$

where l is in metres and f is in MHz.

Windom gave his offset (from centre) as L x 0.14 or (14%). The true OCF dipole must use coaxial or parallel transmission line to eliminate feeder radiation. Two popular amateur handbooks give the offset as L x 0.167 or 16.7%. I have also seen designs with an offset of L x 0.174 or (17.4%). There seems to be a bit of variation.

The objective of these offsets is to strike a spot on the antenna off-centre that has an impedance of around 300 ohms resistive. If this sweet spot can be found, then a 4:1 or 6:1 balun can be used to provide a match close to 50 ohms.

Even if the impedance varies around 300 ohms a balun will bring the impedance close to 50 ohms. Some designers use a 6:1 balun. I find a 4:1 is all that is necessary if the right spot can be found. The problem with finding

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the exact spot off centre is complicated in my view by unpredictable variables. The best that can be achieved is close and then practical adjustments have to be made to the antenna. Wire antenna characteristics are always a bit rubbery. You can not take designs out of a book and expect the exact same results in any two locations. This does not matter in practice. Where exactly we will find 300 ohms off-centre is dependent on the height above ground, type of ground, other nearby antennas or objects, wire diameter, and so on.

So, what is the correct distance off-centre? Well, it is not possible to give an exact distance. For a dipole about 10-15 metres above ground, the distance from the centre to the 300 ohm feedpoint is between 30-35% of the length of the antenna. Or 15-17.5% off-centre. Middle ground is very close to 33.3% from one end. In other words the best place to start is to place the feedpoint one third of the antenna length from one end. I stick to these dimensions as it is easy and very close to ideal and we have a 1/3 – 2/3 antenna. Figure 2 shows the dimensions of an OCF dipole for 80 metres. The impedance one third of the way from the end should be between 200 and 400 ohms and, of course, resistive.

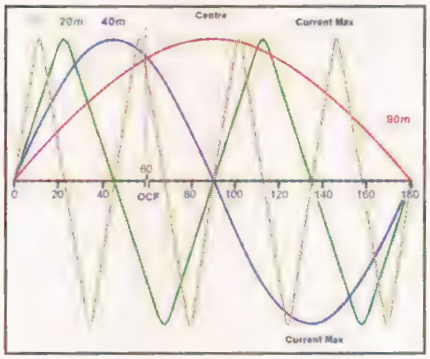

Figure 3: A visualisation of the impedance at different places on any antenna.

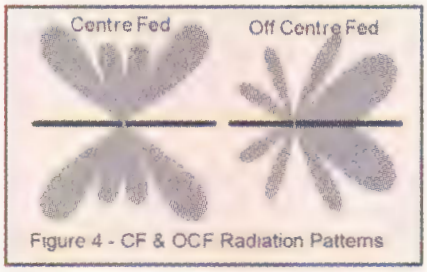

Figure 4: CF and OCF radiation patterns.

Note: When on 80 metres I operate usually much lower down than 3.7 MHz and, in fact, the SWR is very flat even if you vary these dimensions by up to 400 mm. I have found that a good, neat, and easy to remember size for an 80-metre OCF is 27 metres one side and 13.5 metres the other. I use 1.25 mm galvanised iron wire because it is cheap, strong, hard-to-see and is stretch resistant. However, you can use any wire that you like.

Once up, you can test measure the SWR on 80 metres and adjust the length by adding or subtracting to both sides. You are adjusting for minimum SWR not a 1:1 SWR.

An ordinary centre-fed-dipole has a low impedance at the resonant frequency and at odd multiples of that frequency. A centre-fed dipole resonant on 7 MHz will also have a current loop (a current maximum) or low impedance at the third harmonic on 21 MHz.

If you are going to use a centre-fed dipole on multiple bands, you really need to cope with high SWR and use a parallel wire feeder to minimise transmission line loss. On the other hand an off-centre-fed dipole fed 1/3 rd the length from one end will have about 300 ohms impedance at the resonant frequency

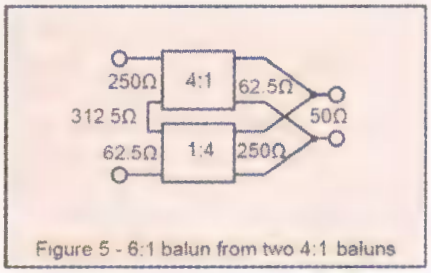

Figure 5: 6:1 balun from two 4:1 baluns.

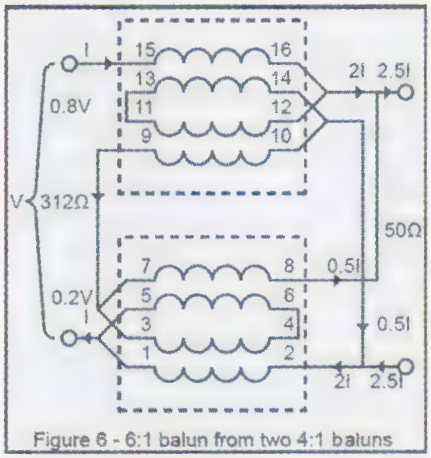

Figure 6: Circuit of a 6:1 balun from two 4:1 baluns.

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and at all even harmonics. The antenna in Figure 2 is resonant on 80 metres and has a feedpoint impedance of about 200-300 ohms which is transformed to be close to 50 ohms by the 4:1 balun. This dipole also has roughly the same input impedance on 80, 40, 20, 10 and 6 metres. Pretty good, eh!

Now that is a far more useful antenna. If adjusted correctly, you can easily get five bands of operation from the one antenna with little or no tuning. A tuning unit will allow operation on other bands as well but the SWR will be quite high on some resulting in increased feedline loss.

Looking at current distribution

Figure 3 shows a very useful and simple technique for visualising the impedance at different places on any antenna. The horizontal line in Figure 3 represents a half-wave antenna. I have marked off the length of the antenna in degrees from 0-180. The antenna is resonant on the 80-metre band. Most of us are very familiar with the current distribution of a half-wave dipole shown in red. Have a look at Figure 3 and ignore all except the red curve and you will see the current distribution of any half-wave antenna.

As you would expect, the current is maximum in the centre (90 degrees) and minimum at each end (0 and 180 degrees). There is no need to show the voltage distribution. If we did we would draw another set of curves 90 degrees out of phase with those shown. The current and voltage distribution of this half-wave antenna is the same no matter where we attach the feedline. Whether we feed the antenna at the centre, the end or somewhere else in between the current and voltage distribution will be the same as that shown in Figure 3.

Where the current is maximum, the impedance is minimum. The more current, the lower the impedance. If we connected to this dipole in the centre (90 degrees) we are connecting at a high current point and, therefore, a low impedance (from Z=E/I). The typical impedance at the centre of a resonant half-wave dipole is low – about 70 ohms. If we were to connect a typical low impedance feeder to either end (at the low current points) where the impedance is high, we would need to use some sort of impedance matching device. For example, the matching section of a J-pole allows us to connect a coaxial line to the high impedance end of a half-wave antenna.

Suppose we were to use this 80-metre dipole in Figure 3 on 40 metres. The current distribution for 40 metres is shown in blue. We get a full cycle of current distribution because the antenna is now a full wavelength. Notice how the current at the centre (90 degrees) of the antenna on 40 metres is now at minimum. The impedance will be high, indeed, very high, this dipole would not work on 40 metres unless we had a special matching system or tuned feeders. This antenna will not have a low impedance at its centre again until we tune it to its third harmonic – that is the 15-metre band (21 MHz).

The principle behind the OCF dipole is to find a compromise point on the antenna where the impedance is low enough to connect our feeder – which is usually the coaxial line – and operate on multiple bands. With the OCF we place the feedpoint as shown in Figure 3 at 60 degrees from one end. Have a look at the amount of antenna current at 60 degrees for the 80, 40, 20 and 10-metre bands. The current is not maximum for any of the above bands but the current is high and about the same value for all bands. This means the impedance on 80, 40, 20 and 10 is about the same. The impedance is theoretically about 300 ohms. It is not bad on 6 metres either though this is not shown. In practice, the actual impedance range will vary between 200 and 400 ohms across the mentioned bands. Now, that is a manageable impedance.

With a balun (either 4:1 or 6:1) connected at the feedpoint we will get multiband operation with little and often no tuning at the transmitter. A balun at the feedpoint prevents feeder radiation and transforms the impedance to a lower value close to our coaxial transmission line. Even if the impedance is not 300 ohms the use of a balun to transform by a factor of 6:1 reduces the impedance error by a factor of 6. Suppose we have exactly 300 ohms on any band, this will be transformed by a 6:1 balun to 50 ohms and the SWR is 1:1. What if, for some reason, the impedance is high, say 400 ohms. The balun will transform the 400 ohm too-high impedance to 400 ÷ 6 = 66.7 ohms. Wow! Who cares? It is going to work and work well at 66.7 ohms as the SWR with a 50-ohm line will only be 66.7÷50 =1.3:1. If the off-centre impedance was out in the opposite direction – say 200 ohms, then this is transformed by the balun to 33.3 ohms which is an SWR of 1.5: 1 on a 50-ohm line. Transmission line baluns can tolerate impedance aberrations of this scale. As mentioned, I prefer to use a 4:1 balun as it is a simpler and more lightweight balun.

Performance of an OCF

The OCF dipole is a good non-compromise antenna on its even harmonics. I have heard arguments about how it compares to a conventional dipole. Is it better in terms of antenna gain or radiation pattern compared to a conventional dipole?

Well, the OCF is a half-wave antenna on the lowest band of operation. Our OCF dipole on 80 metres will work as well and have exactly the same characteristic as any dipole on 80 metres.

On the higher harmonics, the OCF will become a progressively longer antenna. On 40 metres our OCF will be a full wavelength. On 20 metres, two wavelengths and on 10 metres, it will be a full four wavelengths. The longer an antenna becomes, the more lobes it will have.

The left side of Figure 4 shows a centre-fed two wavelength dipole and its radiation pattern. There are more pronounced lobes on this antenna but it is still essentially bidirectional. There are four main lobes. The same antenna at double the frequency would be four wavelengths.

More minor lobes will appear in the centre and the four major lobes will drop down closer to the line of the antenna. In other words, the antenna becomes increasingly directional towards the ends, though this is somewhat exaggerated in the diagram.

When we feed such an antenna off-centre, there is a tendency for the radiation pattern to become stronger towards the long side of the antenna. The longer the antenna, the more pronounced is the towards-one-end directivity. So theoretically, our OCF antenna will become slightly directional towards the longer end. However, due to other reflections, this may not be at all obvious to the user. Essentially an OCF is no better in performance than

the centre-fed dipole. The advantage of the OCF is its operation on the even harmonics. The losses are lower because the lower overall SWR means less feedline loss. This antenna is resonant on its harmonics. An SWR is acceptable up to 2.5:1 on typical coaxial runs. Typically though, this antenna will achieve an SWR of between 1.5:1 and 2:1 on most bands and this is great – even 2.5:1 is good but you will need an ATU depending on the type of rig you use. Older radios with output tuning will handle this SWR. There are some bands – for example 30 metres (10.5 MHz) where a low current (and high voltage) will appear at the 60-degree feedpoint. See Editor's note. Could you use this antenna on 30 metres with matching? Well, yes, you could but you can expect the balun not to work well or at all under high SWR. You can expect balun and feedline losses to be high(er). You can expect feedline radiation. If you are okay with all of that, then try it out.

The Carolina Windom!

There is a variation of the Windom and OCF called a Carolina Windom. This antenna is much the same as that shown in Figure 2. However, with the Carolina Windom there is deliberate feeder radiation! I believe this is achieved by the balun at the feedpoint not doing what baluns are meant to do! That is to prevent feeder radiation. With the Carolina Windom it appears that some feeder radiation is desired. That is, some radiation from the feeder is permitted or deliberate! Consequently, the radiation pattern is modified from that of a dipole and allegedly this is an advantage on some communication circuits. I am sceptical. The Carolina Windom has an additional current choke balun on the coax prior to entry into the shack to keep RF out of the station. This is evidence that the balun is not effective.

A balun for the OCF

Because the OCF is not fed at the centre, the RF impedance path for each side of the antenna is different; that is, the currents on each side will be unequal. Knowing the impedance is around 300 ohms, one could be tempted to feed the antenna with 300 ohm ribbon.

Indeed, this would work and may work well but it is no longer an OCF dipole. Because the OCF has unequal impedance each side of the feedpoint then a balanced feeder would become unbalanced and become a radiator! With coaxial cable this also means that antenna current can flow on the outside of the feeder and produce radiation. Feeder radiation is undesirable for many reasons and, in particular, the increased potential for overload to neighbouring equipment (including your neighbour's). In order to prevent it, we need to use a balun at the feedpoint of the OCF.

Which balun to use?

Well, depending on which author you read, you often get different answers. First the impedance ratio seems to vary a lot. A 4:1 balun on the OCF is common. Some commercial OCFs use a 6:1 and there are reports of 9:1 baluns being used.

As mentioned the impedance of an OCF can be expected to vary between 200 to 400 ohms. I think the optimum balun is a 6:1. However, I have used a 4:1 balun and favour it due to its lighter mass. A 4:1 can be strung in mid-air with the dipole tied off at each end. The 6:1 balun that I have used comprising two 4:1 Guanella baluns is configured to give a 6: 1 impedance transformation. In my view, Guanella baluns withstand higher deviations in impedance and SWR than Ruthroff baluns.

A 6:1 balun

Whilst not the only method, it is easy to make a 6:1 balun from two 4:1 baluns. The same method can be used in other applications and other impedance transformations so it is worth having a close look at the technique.

Figure 5 shows the block diagram of the method. Here we see two 4:1 Guanella-type transmission line baluns (I will show you how to build these devices shortly). In our case they would be transmission line baluns but for other applications they could be other types of devices. We want an impedance transformation of 6: 1 (or 1:6) to connect a 50-ohm coaxial line to a feedpoint on the OCF of about 300 ohms.

A transmission line balun designed for the impedance ratio 100:25 would not work as well (if at all) in a network with 200 and 50 ohm impedances even though the ratio is the same. The exact ratio of the design in Figure 5 is 312.5 to 50 or 6.25:1. For practical purposes

Figure 7: A commercial 4:1 Guanella balun.

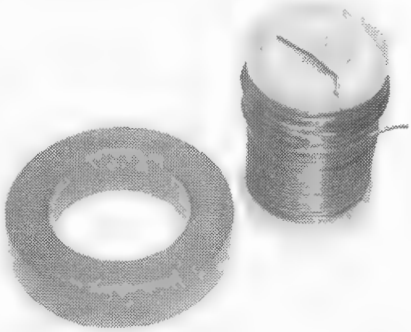

Figure 8: FT140-61 core plus enamelled wire.

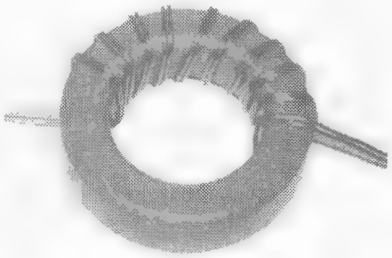

Figure 9: A 1:1 Guanella balun.

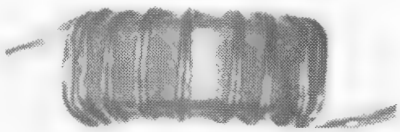

Figure 10: Side view of 1:1 balun.

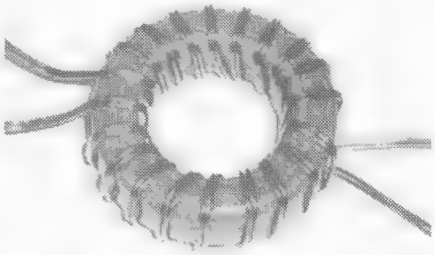

Figure 11: Two 1:1 Guanella baluns.

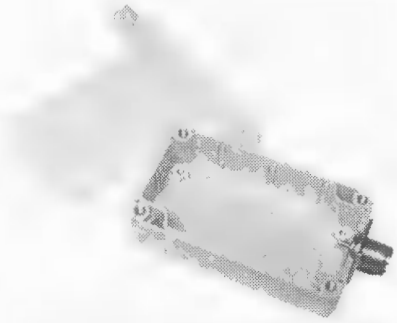

Figure 12a: Box with backing board.

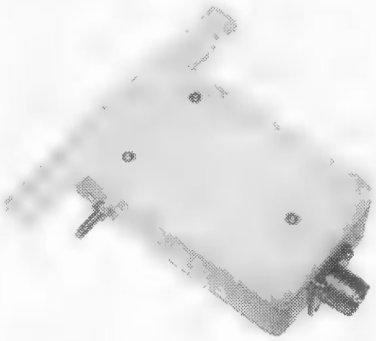

Figure 12b: The backing board fitted on to the box.

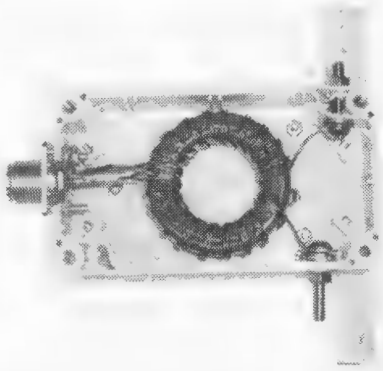

Figure 13: The mounted 4:1 balun – consider using eye bolts instead of the backing board.

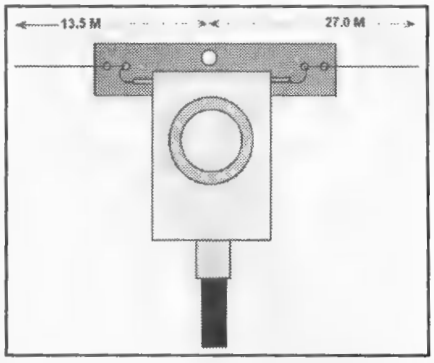

Figure 14: The antenna dimensions.

this is 6:1. Each of the 4:1 baluns is a Guanella balun. Each balun should be made from two transmission lines with a characteristic impedance which is the geometric mean of the input and output impedance for that balun. The optimum impedance for the lines making up each balun is then

$$Zopt = \sqrt{250 \times 62.5} = 125 \text{ ohms.}$$

Each balun should be made from 125-ohm bifilar windings on a toroid former with a permeability of around 125-250.

So how do these two baluns as shown in Figure 5 produce a 6:1 balun? Each balun is identical and has an impedance transformation of 250:62.5. Notice on the left-hand side how the two baluns are connected in series. The 250 ohms of the top balun is in series with the 62.5 ohms of the bottom balun. This gives an impedance on the left side of 250+62.5 = 312.5 ohms. On the right-hand side the two baluns are connected in parallel. Now 250 ohms in parallel with 62.5 ohms is 50 ohms. The block diagram of Figure 5, I hope, helps make this easier to visualise.

Figure 6 is the full schematic diagram showing the transmission lines that make up the two 4:1 baluns and how they are connected to produce a 6:1. The relative currents and voltages are shown on Figure 6 for those who want to look at the operation a bit deeper. The top balun is a 4:1 from left to right. An impedance step down of 4 will produce a current increase (step up) at the output by a factor of 2. The current (and voltage) ratio is equal to the square root of the impedance ratio. So, if the input to the top balun is taken as "I" as shown, then the output current that this balun contributes to the load will be '2I'.

The bottom balun is connected as a 1:4. The output current that this balun contributes to the load is 0.5I. The total current is then '2.5I' for an input current of 'I'. The impedance ratio is:

$$2.5^2 = 6.25$$

which, for practical purposes, is close enough to 6:1.

As you can see a 6:1 Guanella balun is a rather complicated balun. It is also heavy. For this reason, I make a small compromise and settle for a single 4:1 Guanella balun for the OCF dipole. I have no problems with my OCF and a 4:1 balun. My highest SWR is 2:1 on any band. On 80 and 20 it is closer to 1.5:1. Please remember that these are very good Standing Wave ratios for a resonant antenna.

The Australian-made XRF-4 (4:1) is a high-quality, low-loss, Guanella balun. This balun is also fully encapsulated for superior weatherproofing. For more information on this balun visit http://xrf.redirectme.net/

Building your own 4:1 Guanella balun

To make the 4:1 balun you will need some enamelled wire. The impedance of the parallel line used to make this balun is 100 ohms. 1.0 mm enamelled wire with no spacing provides a characteristic impedance close to 100 ohms. A wire diameter from 0.8 to 1.2 mm will be adequate for the job. You will need about 3 metres of the wire.

The toroidal core needs to be the correct permeability and the right size to get the required transmission line turns. I suggest an FT-140-61 material. FT (Ferrite Toroid) 140 is about 40 mm outside diameter. Type 61 material has a permeability of 125. Cores with permeability between 125 to 250 are the best choice for this balun.

The start of a 4:1 balun is, in fact, a 1:1 balun. Take about 1.8 metres of wire and fold it in half. You have made a short length of 100 ohm transmission line. Now, mostly using your thumb, wind this line around the core. You need 7-8 turns. You are not winding a transformer. What you are doing is winding a short length of parallel transmission line around a ferrite core. Do not let the wires twist or overlap. Keep the pair of wires close together. These wires are a transmission line. They are not the windings of a transformer. The line should be kept flat and close together otherwise the characteristic impedance will alter.

You do not want the parallel line to drift apart with handling. To prevent this you could use cable ties to hold the line together. My preferred method is to tack the line in position on the toroid with spots of Araldite. A hot glue gun would work just as well. You have now made a 1:1 balun on one side of the toroid. The next step is to make another 1:1 balun on the other side of the toroid as shown in Figure 11.

You end up with four wires in each end of the toroid as shown. What you have is two 100 ohm transmission lines on the

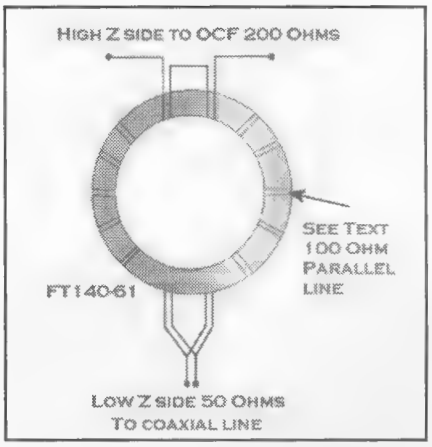

Figure 15: Balun wiring.

core. These lines are parallel connected on one side to give an impedance of 50 ohms. On the other side the two lines are connected in series to give an impedance of 200 ohms. Thus we have a 50 to 200 ohm Guanella balun. On one side of this balun you will be connecting your 50 ohm line and the other side will go to your OCF dipole. If you were using a standard dipole you would not use this balun, instead you would use a 1:1 Balun made with 50-ohm coaxial or parallel line. The toroid and the lines of the 4:1 balun cannot take much mechanical stress plus it is a good idea to waterproof the whole lot so we need to house the balun somehow.

The XRF balun shown in Figure 7 is fully waterproofed in epoxy resin. Almost any plastic instrument case mounted on a plastic backing board will do. Plastic sheets can be obtained easily and cheaply by purchasing plastic cutting board. I purchased a set of five boards for $12 which provides enough plastic sheet to make 12 baluns.

The photo in Figure 12 shows how the plastic sheet is cut to fit the size of the box you have. The sheet is very easy to cut using a hacksaw and a jigsaw is even easier. The sheet is extended away from the box at the top and has holes drilled for the dipole wire connection. Figure 12 shows the box with backing board. The box shown is a little expensive (about $7). A box which is designed to be mounted on to a flat surface can be purchased from a parts supplier for about $5-6. An SO-239 socket has been mounted on one side of the box for the 50 ohm cable connection. An alternative is to have the coaxial cable go straight to the low impedance side of the balun

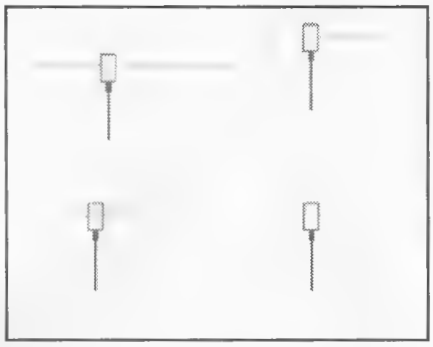

Figure 16: Running the antenna wire.

and fix it to the cutting board with at least three cable ties.

An alternative to the backing board shown in Figures 11 and 12 is to use eyebolts as shown on the XRF 4:1 balun. If you are going to make a mistake in the construction of the balun it will be in the connection of the two transmission lines at each end. On one side the two 100 ohm lines are connected in series (the high impedance antenna side of 200Ω) and on the other side the two 100 ohm lines are connected in parallel (the low impedance 50Ω line side).

To make this a little clearer, refer to Figure 15 below. Here you can clearly see the series connection on the high impedance side (that goes to the antenna) and the parallel connection on the low impedance side.

Many of us are limited by the height we can have our antenna and often, on 80 metres, we are pressed for space. The overall length of my OCF for 80 metres is 40.5 metres (27 + 13.5). I have a straight run at about 10 metres height. However, you can treat the OCF like any half-wave horizontal dipole and bend the legs in various configurations as shown in Figure 16. If it is difficult for you to get height, consider the inverted "V" configuration. It is the centre of the antenna (where most of the radiation occurs) that should be as high as possible. The ends can be brought lower down and terminated through insulators to a building, pole or fence line.

A bit more about baluns

Just to round off, I would like to talk a little more about baluns. I don't recommend a 9:1 balun for the OCF antenna. However, I thought I might include the circuit diagram of a 9:1 Guanella balun since

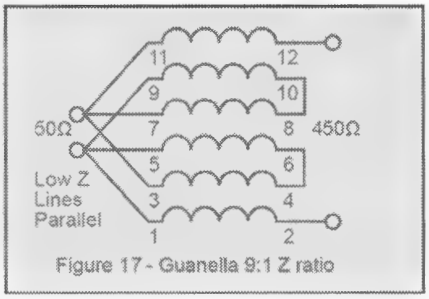

Figure 17: Schematic diagram of a 9:1 Guanella balun.

we have already covered the 1:1, 4:1 and 6:1. I may as well finish off with the 9:1 just for completeness. This may also help consolidate how these and other transmission line baluns really work as well.

Now Figure 17 does look a bit complicated but please take the time to have a good look at it. Recall how the 4:1 balun was simply two 100-ohm transmission lines on a toroid. Series connected on one side to give 50 ohms and parallel connected on the other to give 200 ohms. In Figure 17 we have three transmission lines: 1-3 on the left goes to 2-4 on the right – that is one transmission line. This 9:1 balun transforms 450 to 50 ohms. The geometric mean of these two impedances is

$$\sqrt{450 \times 50} = 150\Omega$$

So you would have to use the appropriate wire size and perhaps adjust the spacing to make three parallel lines each having a characteristic impedance (Zo) of 150 ohms. You can use the standard equation for calculating the Zo of a parallel line. The two wires could be held the correct distance apart by hot glue or sleeving before you wind them on the toroid.

On the right-hand side the three lines are in series to give 450 ohms. On the left-hand side the three 150 ohms lines are paralleled to give 50 ohms. If your three lines were not 150 ohms you would still have a 9:1 balun, it would just not be 450:50 – the 9:1 ratio would be the same but the input and output impedances would vary according to the characteristic impedance of the lines you use. By the way you can use coaxial cable to make these baluns. However, it is difficult to get a broad range of impedances with coaxial cable. The most common impedances for cables are 50,

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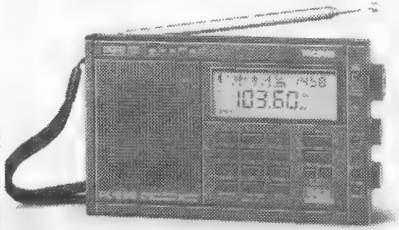

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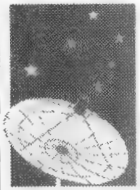

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Understanding and building the OCF dipole antenna

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75 and 90 ohms.

I hope that has put to bed once and for all that transmission line baluns, Guanella (current) and Ruthroff (voltage), are not transformers. Properly wound baluns such as those discussed are very efficient devices. Guanella (and Ruthroff) baluns are not conventional (mutually coupled) transformers. There is no primary or secondary. There is no turns ratio. There is no magnetic coupling between the windings. The Guanella balun described should have an efficiency of around 97% or more. So, almost no power is dissipated in the balun. The wire size matters. There is a right size and bigger is not better. Remember you are making two transmission lines on the toroid not a transformer. Because of the high efficiency (low loss), this balun should handle up to 1,000 watts of power.

As far as the forward power to the antenna is concerned there is no ferrite core. This is because we have transmission "through two transmission lines". There is no external flux around transmission lines. However, if the antenna is unbalanced, there will be leakage or common mode current flow through the balun. These currents are not transmission line mode currents. These currents will see a choking reactance presented by the balun and be stopped or significantly reduced. These leakage currents if extremely excessive can cause heating of the balun (but you have probably got a serious problem that you need to fix). Very high SWR can cause voltage dielectric loss and even flashover between the windings. Again this would indicate a more serious problem with the antenna.

Have fun with your OCF dipole.

ar

Editor's note: *Equally some modern rigs with semiconductor finals do not tolerate even mild SWRs. In fact circuitry is often included to reduce the RF drive should the SWR rise. If using such a transceiver, the use of an ATU might be worthy of consideration.*

Off Centre Fed dipole (OCF)

Ron VK3AFW

Ron VK2DQ is to be congratulated on his excellent article on the OCF dipole (AR Jan-Feb 2009) and the baluns he used. There are three points on which I would like to comment.

Yes the wire is a feed line.

The single wire feed line has been credited to Frank Conrad 8XK of Westinghouse. Major General Loren G Windom published comments on adjusting an OCF antenna in QST in July 1926 and in QST Sept 1929 published an improved design. It was stated by him to be a description of work done by two students Everitt and Byrne in his faculty. The first use of the name "Windom" appears to be by the Wireless Institute of Australia which in 1930 published an article which was substantially a reprint of Windom's QST article.

A single wire parallel to the ground provides a feed line with a characteristic impedance between about 100 and 400 ohms depending on its height above ground. The earth forms one part of the transmission line and the wire the other part. If the wire slopes then it no longer has constant impedance. The section nearer the ground has a lower impedance and the higher part a higher impedance. This means that it will have a standing wave due to mismatch no matter whether it is terminated in its characteristic impedance at the matching port or terminated by some other resistive load. The VSWR when connected to a Windom will typically be in the region 2:1 to 5:1 at resonance. This is acceptable for a wire transmission line.

So Windom was able to feed his half wave dipole with a single wire and get much of his transmitter's power to be radiated by the horizontal section. His 40 m signal was said to be outstanding.

There is no doubt that the wire feeder will radiate maybe 25% of the power it is fed and that this will be largely vertically polarized.

By bringing the feeder away from the antenna at right angles for a respectable distance the problems of noise pick-up, excessive feeder radiation and interaction of the radiation patterns could be kept within acceptable bounds.

The quarter wave mentioned seems to have gained currency for no good reason. A greater distance would be better.

Of course these days we can avoid the radiation from the feeder by using a coax feed and a balun, but neither existed in the 1920s. It also means that the feed line can be any length without much consideration of possible interactions with the dipole or the environment, providing it runs at right angles to the dipole for a reasonable distance (a quarter wave maybe?).

The second point is that contrary to what is said by many the antenna does not resonate at exact even multiples of the fundamental resonant frequency.

Due to the "end effect", the 40 m resonance for example occurs higher than twice the 80 m frequency. This can be explained as follows:

The 80 m resonance is reduced by about 5% over the theoretical free space length based on an infinitely thin conductor. On 40 m the antenna is two half waves, and the two "ends" of the half wave that occur along the dipole are unaffected by end effect, so the 5% frequency reduction does not apply. The ARRL "Handbook" (p 595, 1977 Ed) gives a formula as follows:

$F = 150 * (N-0.05)/L$

where F is the resonant frequency in MHz, N is the number of half waves and L is the dipole length in metres. (I have made the conversion from feet to metres for this letter).

If the 80 m resonance is on 3.60 MHz, then the even harmonics are actually: 7.58, 15.16, 22.74 and 30.31 MHz. I have found the ARRL formula to be pretty close to what happens in practice. These numbers also agree well with an antenna simulation software program that I have run in the past.

Adding capacitance hats to the dipole at the voltage peak point for 40 m will help on this band but additional capacitance hats will be required for all voltage peaks on each band, making the antenna more complex to build.

The use of an ATU cannot be avoided except perhaps on one band.

Finally, the feed impedance may be about half the figures given by Ron if the dipole is in an inverted vee configuration. I have also found that at an average height of 10 m the feed resistance at resonance for the 1/3 tap point varies from around 100 to 200 ohms. This has been checked by both simulation and measurement. One author suggests using an 80/20 tap position so that 30 m presents a useable VSWR. I have not investigated this suggestion.

While there is no simple cheap antenna that gives fantastic performance on all HF bands, Carolina Windom included, the OCF does a commendable job on three bands. The SWR etc will be dependent on any variations in the design and the actual installation details.

ar

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